MIL-M-47230(MI)
26 July 1974
SUPERSEDING
MPD-10566A
1 November 1968

MILITARY SPECIFICATION

MAGNETIC PARTICLE INSPECTION: SOUNDNESS REQUIREMENTS FOR MATERIALS, PARTS, AND WELDMENTS

This specification is approved for use by all departments and agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification describes the defect limits allowed under three quality level classifications for the magnetic particle inspection of ferromagnetic forgings, castings, tubes, sheets, bars, etc., in the following fabrication stages:

a. Unmachined or unwelded parts or materials.

b. Machined parts.

c. Weldments; for purposes of this specification, the term weldment refers to deposited filler metal and areas of base metal adjacent thereto which are likely to be affected by the welding operation.

2. APPLICABLE DOCUMENTS

2.1 Government documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal form a part of the specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-I-6868 Inspection Process, Magnetic Particle

FSC-THJM

STANDARDS

Military

MIL-STD-109	Quality Assurance Terms and Definitions
MIL-STD-410	Qualification of Inspection Personnel (Magnetic Particle and Penetrant)

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contraction officer.)

3. REQUIREMENTS

3.1 Inspection standard classification. At the fabrication stage indicated (see 6.3), weldments, materials, structures, parts, or areas thereof shall be inspected to quality level classification A, B, or C as specified on the drawing, purchase order, or other applicable document. If no classification is specified, inspection shall be to the Grade C level.

3.1.1 Grade A. The Grade A classification is applicable to units which are critical with regard to mechanical finishes or dynamic stresses and which warrant the use of selected materials or above-average practices. Grade A represents the highest degree of surface soundness obtainable under this specification and normally is called for in areas of fillets, mechanical grooves, holes, sharp edges, or other sections subject to fatigue or shock in service. Grade A may also be called for as requirement for machined surfaces of castings if only very small discontinuities are allowable.

3.1.2 Grade B. The Grade B classification is applicable to units subject to high but well-distributed static stresses.

3.1.3 Grade C. The Grade C classification is applicable to moderately stressed units.

3.2 Soundness requirements. For the grade specified, defects as revealed by the magnetic particle process shall not exceed the limits shown in Tables I and II, as applicable. Both clear and borderline indications (the latter are indications that do not clearly identify defects as to type, depth, or cross-sectional path) shall be subject to rejection or further exploration if critically located or patterned. Defects that will be removed by machining operations are not rejectable.

Table I - Maximum defect sizes (in inches) and distribution; areas other than weldments

Type of defect (see section 6)	Grade A	Grade B	Grade C
Nonmetallic inclusions, rounded:			
Surface	1/32 dia D-3*	3/64 dia D-3*	1/16 dia D-3*
Subsurface	3/64 dia D-3*	1/16 dia D-3*	3/32 dia D-3*
Nonmetallic inclusions, stringers:			
Surface	1/8 long DD-1*	3/8 long DD-1*	3/4 long DD-1*
Subsurface	3/16 long DD-1*	1/2 long DD-1*	1-1/8 long DD-1*
Seams or laps (unmachined surfaces)	1/2 long DD-1*	1 long DD-1*	1-1/2 long DD-1*
Seams or laps (machined surfaces)	0	0	1/4 long DD-1*
Propagating defects (cracks, cold shuts, shrinks, flakes, pronounced laminations, etc.)	0	0	0
Gas hole porosity (castings):			
Surface	1/32 dia** D-3*	3/64 dia** D-3*	1/16 dia** D-3*
Subsurface	3/64 dia** D-3*	1/16 dia** D-3*	3/32 dia** D-3*

*Distribution designations signify the following:

D-3 Defects no closer to each other than three times the maximum size.

DD-1 Defects no closer to each other than 1/2 inch lineally and 1/4 inch in a parallel direction.

**The requirements for gas hole porosity for the individual grades do not apply if the voids are less than one-half the maximum sizes specified and are well dispersed.

Table II - Maximum defect sizes (in inches) and distribution; weldments

Type of defect (see section 6)	Grade A	Grade B	Grade C
Cracks, weld or base metal (longitudinal, transverse, star or crater, underbead, underside, etc.)	0	0	0
Weld undercutting or lack of bead-edge fusion:			
Base metal less than 3/16 inch thick	1/64 deep, 1/8 long D-5*	1/64 deep, 1/4 long D-5*	1/32 deep, 1/4 long D-5*
Base metal 3/16 inch thick and over	1/32 deep, 1/8 long D-5*	1/32 deep, 1/4 long D-5*	3/64 deep, 3/8 long D-5*
Weld metal voids or inclusions, rounded:			
Base metal less than 3/16 inch thick	1/64 dia D-5*	1/32 dia D-5*	1/16 dia D-5*
Base metal 3/16 inch thick and over	1/32 dia D-5*	1/16 dia D-5*	1/8 dia D-5*
Weld metal voids or inclusions, elongated:			
Base metal less than 3/16 inch thick	1/16 long D-5*	1/8 long D-5*	3/16 long D-5*
Base metal 3/16 inch thick and over	1/8 long D-5*	1/4 long D-5*	3/8 long D-5*

*Distribution designations signify the following:

D-5 Defects no closer to each other than five times the maximum size.

3.2.1 Subsurface defects (other than weldments). The allowable size and distribution of subsurface defects in the form of inclusions and voids shall be as shown in Table I. Small, round, dispersed discontinuities will not normally be revealed by the magnetic particle process if more than a few thousandths below the surface.

3.2.2 Subsurface defects (weldments). When there are indications of incomplete penetration or lack of interfacial fusion of the base metal and deposited weld metal, the length limits shown in Table II for elongated voids or inclusions are applicable. The shape, intensity, location, and arrangement of all subsurface phenomena should be carefully evaluated since allowable base metal gaps or root openings may also be shown by magnetic particle patterns.

3.2.3 Nonrelevant indications. Parts shall not be rejected because of incidental concentrations of magnetic particles in areas which are not defective. Nonrelevant indications may appear on fillets, weld beads, or other areas, particularly if there is surface roughness.

3.2.4 Microsegregations. The appearance of indications due to microsegregations (see 6.4.3) shall not be cause for rejection.

3.2.5 Review of indications. All questionable indications shall be carefully reviewed, preferably under low-power magnification. Usually, significant indications may be identified by the relative sharpness of outline and the tendency of particles to "stand up." If dimensional tolerances and other circumstances permit, exploration of defects by lightly filling or grinding surfaces (with reapplication of indicating medium) is recommended. The judicious use of a suitable tool such as a feeler gage or scriber may be helpful in establishing the significance of indications.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Verification inspection (Government). All quality assurance operations performed by the contractor will be subject to Government verification at scheduled or unscheduled intervals. Verification will consist of (a) surveillance of the operations to determine that practices, methods, and

procedures of the written inspection plan are being properly applied, and (b) Government product inspection to measure the quality of the product offered for acceptance. Deviation from the prescribed or agreed upon procedures or instances of poor practices which might have an effect on the quality of the product will be immediately called to the attention of the contractor. Failure of the contractor to promptly correct deficiencies discovered shall be cause for suspension of acceptance until correction has been made or until conformance of product to prescribed criteria has been demonstrated. To avoid interference with operations, the contractor shall designate a responsible offical or officials to whom the Government inspector will report such instances.

4.3 Definitions. The definition of inspection terms shall be in accordance with MIL-STD-109.

4.4 Equipment verification. The Government inspector, when examining the contractor's inspection equipment, will determine that the contractor has available and utilizes correctly gaging, measuring, and test equipment of required accuracy and precision and that the instruments are of a proper type and range to make measurements within the required accuracy.

4.5 Examination schedule. Unless otherwise specified, 100 percent of the items in an inspection lot shall be examined. Any sampling plan shall be as agreed upon by the contractor and the procuring activity.

4.6 Acceptance inspection. Acceptance inspection of parts, weldments, and materials shall be in accordance with procedures specified in 4.11 and to the quality levels specified in applicable design or procurement documents. Allowable discontinuities under the specified level, at the fabrication stage indicated, shall be as described in Tables I and II and related requirements.

4.6.1 Areas for particular surveillance. Special attention should be given to the surveillance (within specified requirements) of highly finished surfaces, weldments, abrupt changes in section, and areas around drilled holes.

4.6.2 Nonrelevant indications. As specified in 3.2.3, care should be exercised in interpretation to avoid rejection of parts due to nonrelevant indications.

4.6.3 Removal defects. Parts containing defects which may be removed by subsequent work will require reinspection after completion of the subsequent work.

4.7 Equipment and indicating media. All equipment and indicating media provided shall conform to MIL-I-6868.

4.7.1 Magnetizing apparatus. The magnetizing equipment shall be capable of providing both circular and longitudinal magnetization of the required magnitude.

4.7.2 Indicating media. Only approved dry powders, fluorescent suspensions, and nonfluorescent suspensions shall be used.

4.7.3 Fluorescent apparatus. If the fluorescent method of magnetic particle inspection is used, suitable black-light sources and darkening inspection booths shall be provided.

4.7.4 Demagnetizing apparatus. Demagnetizing apparatus provided shall be capable of completely demagnetizing the parts being inspected.

4.7.5 Cleaning equipment. Suitable equipment shall be provided for cleaning all parts before and after magnetic particle inspection.

4.8 Maintenance.

4.8.1 Equipment and procedures. Periodic checks shall be made to assure the effectiveness of the magnetic particle inspection equipment and procedures.

4.8.2 Suspension. One of the tests outlined in MIL-I-6868 for the determination of the magnetic substance content of suspensions shall be performed at least once each 8 hours of operation.

4.9 Certification of personnel. As required by MIL-I-6868, all magnetic particle inspection personnel shall be certified in accordance with MIL-STD-410.

4.9.1 Responsibility. The inspector shall be responsible for interpreting defects and making disposition. Rejected parts shall be processed by the contractor's Material Review Board.

4.10 Preparation for inspection. Before inspection, it shall be ascertained that parts have been properly cleaned and are free from grease, oil, scale, dirt, paint, and similar finishes and that oil holes and other openings leading to inaccessible areas have been sealed with a suitable material.

4.11 Inspection procedure. The magnetic particle inspection shall be in accordance with MIL-I-6868.

4.11.1 Magnetization. Unless otherwise specified, all parts inspected shall be magnetized so that the magnetic fields induced in the part will occur at an angle of not less than 45 degrees to the direction of any possible defect.

4.11.1.1 Circular. Circular magnetization consists of inducing a circular magnetic field in the part so that the lines of force take the form of concentric rings about the axis of the current. The current shall be passed directly through the part or through a conductor which passes into or through a hole in the part. Contact surfaces of the parts and contact heads shall be kept clean. Excessive currents which may cause localized overheating of the piece must be avoided. This type of magnetization indicates discontinuities or defects parallel to the current flow.

4.11.1.2 Longitudinal. Longitudinal magnetization consists of inducing a magnetic field in the part so that the lines of force extending through the part are approximately parallel to the axis of the magnetizing coil. The magnetic field is created by a solenoid or other suitable coil, wire, or cable. This type of magnetization is suitable for defects essentially transverse to the axis of the coil.

4.11.2 Method.

4.11.2.1 Continuous. The continuous method consists of applying the suspension of magnetic particles or dry powder to the work to be inspected while the magnetizing current is flowing.

4.11.2.2 Residual method. The residual method consists of applying the suspension or dry powder to a part retaining residual magnetism after magnetization.

4.11.3 Selection of technique. Unless otherwise specified, all parts shall be inspected by the continuous method. When hardened steel parts are inspected, the residual method may be used subsequent to the continuous method to produce more sharply defined indications of minute surface defects or when existence of certain defects is questionable. The circular method shall be used for detection of defects with axes approximately parallel or radial to the axis of the magnetizing current. The longitudinal method shall be used for detection of defects with axes approximately transverse to the magnetizing coil. The fluorescent suspension is recommended for locating defects in inaccessible areas such as internal corners, roots of threads, and bottoms of splines and holes.

4.11.4 Magnetizing current magnitude. A magnetizing current from 800 to 1200 amperes per each inch of the part's outside diameter should be used for circular magnetization. For fixed solenoids or flexible coils wrapped about the part, 8000 to 10,000 ampere-turns should be used. Flexible coils should consist of six to eight turns with approximately one turn per inch. The duration of the current shot shall be from 1/5 to 1/2 second, and in no case shall exceed 1/2 second.

4.11.4.1 Optimum current density. To assist in establishing optimum current densities, parts with known defects should be inspected, starting with low current levels and increasing until adequate indications are obtained. In circularly magnetizing parts having contacting surfaces of

dissimilar size, the current needed for the smaller dimension should be used first.

4.12 Demagnetization. Parts shall be demagnetized between successive magnetizing operations when necessary to obtain sharper indication of defects. All parts shall be satisfactorily demagnetized after inspection is completed. Parts may be tested with a magnetic field indicator for presence of residual magnetism produced by longitudinal magnetization.

4.13 Cleaning. After demagnetization, inspected and approved parts shall be thoroughly cleaned, using a suitable solvent to remove magnetic oxide particles.

4.14 Identification. Unless otherwise specified, units that have been inspected by the magnetic particle inspection method shall be etched with the applicable symbol shown in Table III. When etching is not practicable, the inspected units shall be tagged or impression stamped with ink. Impression stamping, when approved by the procuring activity, shall be adjacent to the part number. Tags shall be stamped with ink for use on units whose construction, finish, or functional requirements preclude the use of etching or stamping.

Table III - Inspection symbols

Inspection	Symbol
Physical inspected and accepted	M
Accepted on sampling plan but not physically accepted	M
Unacceptable	Reject

4.14.1 Serial indentification. When serial identification is required, the serial number or symbol specified by the procuring activity shall be placed on units, tags, and reports.

4.15 Inspection reports. A report of magnetic particle inspection shall be submitted to the procuring activity. The report shall include all information necessary for the understanding of the inspection test results such as serial numbers, grade of inspection, unit name, unit number, number of units in the lot, and lot number. If rejected units are reported, the identity of the defects on which rejection is based shall be included. If a sampling plan is authorized by the procuring activity, the report shall include the sampling plan used and the method of selecting the samples.

5. PREPARATION FOR DELIVERY

This section is not applicable to this specification.

6. NOTES

6.1 Intended use. This specification, when used with applicable documents, is intended to establish standards of acceptance for units inspected by the magnetic particle inspection method.

6.2 Ordering data. Procurement documents should include the following:

a. Title, number, and date of this specification.

b. Required soundness grade(s) (see 3.1).

c. Applicable sampling plan if other than 100 percent (see 4.5).

6.3 Definitions.

6.3.1 Critical areas. In terms of quality level classifications as shown in Section 3, design engineers should indicate on drawings the more critical and the less critical areas of units with regard to stress concentration and mechanical finishes. This is in the interest of overall efficiency, including cost control, and can be particularly important to manufacturing, procurement, and quality control activities.

6.3.2 Fabrication stage. Under ordinary circumstances, it is reasonable for the designer of a finished unit to expect that the soundness levels selected will be enforced as a part of the final inspection procedures and to specify that the requirements are applicable after machining, after welding, after blast cleaning, etc. It does not necessarily follow, however, that the quality levels specified for the finished unit should be included as part of the purchase requirements for bars, plates, unmachined castings, unmachined forgings, or other forms. In specifying raw stock for units subject to severe final inspection requirements, due consideration should be given such factors in relation to the possible cost of rejection of finished parts made of materials of regular quality.

6.4 Identification of defects. Following are definitions of certain of the defects and indications thereof covered in Section 3. When types of indications which cannot be identified otherwise are encountered in critical locations, metallurgical examination of sample parts by destructive methods may be necessary.

6.4.1 Cracks. Of the various types of propagating defects, those caused by stresses induced by such processes as heat treating or grinding are often the most difficult to discover unaided, due to fineness of line and pattern. The magnetic particle inspection process is particularly useful in detecting defects of this type, which may have a radial or latticed appearance.

6.4.2 Inclusions. Inclusions are round or elongated nonmetallic particles which may appear on or near the surface of various products, but which are not considered harmful if relatively small and well dispersed. However, if they appear in clusters or stringers or if abnormally large individually (for the quality level specified), they are indicative of materials or practices of questionable quality.

6.4.3 Microsegregations. Under magnetic particle inspection, metallurgical phenomena known as microsegregations may be revealed as extremely narrow lines, usually long and straight, on the surfaces of highly finished parts made of wrought metals. Usually they will have no "feel" when explored with the top of a sharp object, and a given line will often disappear if a few thousandths of the surface is removed. While microsegregations as such are not considered harmful, efforts to establish their identity (i.e., to insure that the indications are not due to cracks, deep laps, long inclusion stringers, etc.) are usually justified, especially when first encountered.

6.4.4 Laminations. Laminations may appear as inclusion stringers between the rolled surfaces of material in the form of rectangles or plates; but, in some instances, actual separations may occur in these products. If present, laminations would be indicated on the short transverse section of a unit. Short, intermittent laminations may not be objectionable if the unit is not subjected to high bending stresses. The occurrence of laminations usually can be attributed to faulty rolling mill operations.

6.4.5 Laps. Laps are surface defects appearing as folds or tangential seams in wrought products and usually are produced during hot working operations.

6.4.6 Flakes. Also known as shatter cracks, flakes appear as short, discontinuous fissures in forgings and possibly other wrought products. They are attributed to localized stresses which may occur during cooling from hot work.

6.4.7 Cold shuts. These casting defects are caused by two streams of semi-molten metal coming together inside a mold but failing to fuse. Cold shuts are sometimes referred to as misruns, but the latter term is more correctly used to describe lack of filling of the mold.

6.4.8 Shrinks. Casting defects in this category include shrinkage sponge, of which there are a number of manifestations. Shrinkage sponge areas may include small voids in the form of stringers or bunches, or there may be in evidence a "fingerprint" pattern consisting of semifused seams. Apparently, shrinks are always caused by variations in solidification rates in the mold. In castings of substantial size, shrinks usually can be avoided by proper placement of risers, runners, chills, etc.

6.4.9 Weldment defects. Sketches of typical weldment defects which may be enhanced by the magnetic particle inspection method are presented herein as Figures 1 through 7.

6.4.10 Photographic illustrations. Photographic illustrations of certain defects are included in American Welding Society Welding Handbook and MIL-M-11473, Magnetic Particle Inspection Weldments Soundness.

6.5 Supersession data. This specification includes the requirements of Missile Purchase Descriptions MPD 9178, 9253, 9672, and 10566, dated 1 November 1968.

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Project No. THJM-A060

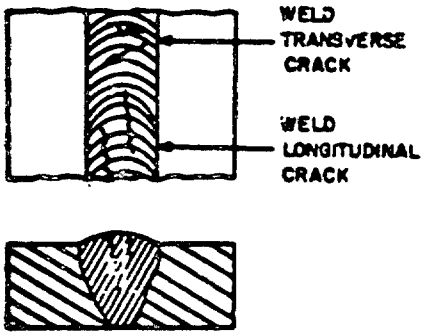

FIGURE 1.

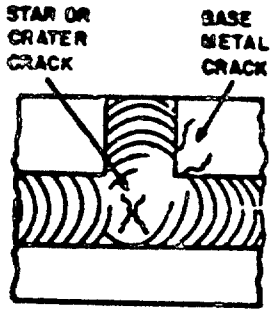

FIGURE 2.

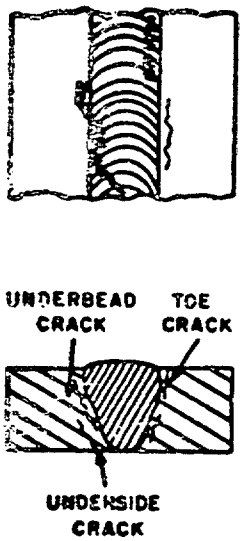

FIGURE 3.

When cracks are present on weld metal or base metal surfaces, magnetic particle indications are relatively sharp and tend to "Stand Up". Indications of subsurface cracks are wider and less pronounced. All cracks are classed as propagating defects and are subject to rejection.

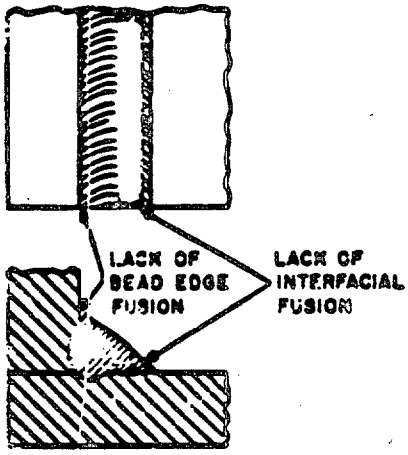

FIGURE 4.

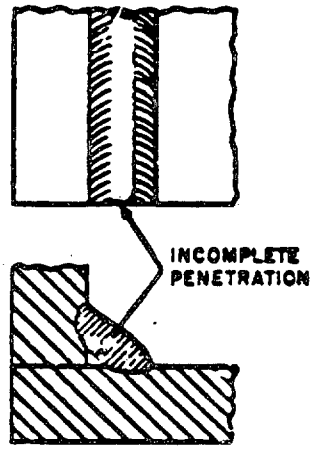

FIGURE 5.

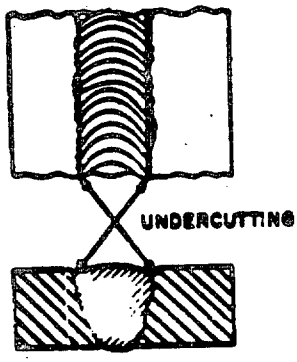

FIGURE 6.

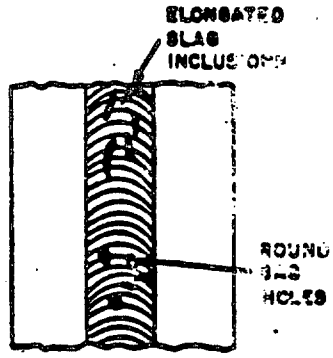

FIGURE 7.

Undercutting and lack of bead edge fusion are often visible without the aid of magnetic particle enhancement. Indications of incomplete penetration and lack of interfacial (subsurface) fusion are usually broad and poorly defined. Intensities of indications of gas holes and inclusions will vary with size and depth.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*: _____
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

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